



**Federal Highway Administration (FHWA) Research and Technology Agenda**

**Meeting the Challenge: Infrastructure**

The United States has one of the most extensive transportation systems in the world, representing trillions of dollars of public and private investment. To fulfill its role as the guardian of this critical highway infrastructure, FHWA is engaged in forward-looking research that supports safety and environmental sustainability while modernizing bridges and roads through better materials, new construction techniques, and consistent quality control. This research increases the highway system's productivity and performance, reduces operational and replacement costs, and ensures a world-class highway system long into the future.

The strength of the infrastructure in the United States depends on quality materials, sound construction techniques, and reliable maintenance practices. Infrastructure research explores emerging technologies that will improve the safety and reliability, structural integrity, and longevity of the Nation's bridges and roadways. A strong infrastructure must also be sustainable and environmentally sound. New pavement materials will have fewer impacts on air quality and ambient noise levels.

Consistent quality assurance methods developed through FHWA research are enhancing design, materials testing, construction, and inspection procedures for roads and bridges. These methods improve how programs are delivered.

**Objective: 1: Improve the security of highway infrastructure and reduce the number of fatalities attributable to infrastructure design characteristics and work zones.**

**Strategies**

- Develop and deploy hazard mitigation, adaptation, and restoration strategies and techniques.
- Develop and deploy methodologies and guidance for assessing safety of infrastructure after a hazard event.

**Showcase Activities**

- Enhancing Hazard Mitigation and Adaptation Countermeasures
- Developing Rapid Post-Hazard Assessment Protocols and Techniques

**Enhancing Hazard Mitigation and Adaptation Countermeasures**

Enhancing Scour Analysis Capabilities and Countermeasures for Inland and Coastal Bridges is among the projects FHWA is pursuing as part of its hazard mitigation and adaptation countermeasures initiative. Scour is the most common cause of bridge failure in the United States. Around bridge abutments or piers, water erosion can lead to scour, which undermines bridge integrity and could lead to instability and eventual bridge failure. FHWA continues to conduct research to better assess why, how, and when scour occurs around inland and coastal bridges. These research studies examine the use of field devices to determine soil erodibility around bridge foundations and the effects of different water pressures on bridge scour. The research will enhance current methodologies and technologies for predicting, evaluating, and mitigating bridge scour in different environments that, when applied, will improve the safety and stability of bridge infrastructure.

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**Additional Resources**

- [Materials Performance for Attack Countermeasures / Multihazard Mitigation Support on Bridges](#)

## Developing Rapid Post-Hazard Assessment Protocols and Techniques

Developing guidelines to assess flooded pavements is among the activities FHWA is pursuing to advance rapid post-hazard assessment of infrastructure. Floods can cause significant damage to roadways. After floods occur, highway agencies need to assess the extent of damage quickly and make necessary repairs to ensure roadway safety and keep traffic moving. FHWA will conduct of moisture on pavement performance. The Agency will work with the European Commission to identify pavement assessment technologies and techniques deployed in Europe that have potential for implementation in the United States. As a result of this research, FHWA will develop guidelines that highway agencies can use to assess the impacts of floods on pavements and how quickly damaged roads can be repaired.

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## Additional Resources

- [Flooded Pavement Assessment Methods](#)

## Objective: 2: Improve the management of infrastructure assets and advance the implementation of a performance-based program for the National Highway System.

### Strategies

- Develop and deploy reliable performance prediction models and practices in the design, construction, and management of the highway infrastructure.
- Develop and deploy sound measures and practices to assess infrastructure condition and assure data quality in infrastructure management and performance predictions.

### Showcase Activities

- Understanding Infrastructure Performance
- Improving Infrastructure Condition Monitoring and Data Management

## Understanding Infrastructure Performance

FHWA's Long-Term Pavement Performance (LTPP) and Long-Term Bridge Performance (LTBP) programs are critical to advancing the understanding of infrastructure performance. FHWA is collecting performance data on warm-mix asphalt as part of the long-term pavement performance research. Traditional hot asphalt mixes require a significant amount of fuel consumption to create the high temperatures needed to produce and place the asphalt. Warm-mix asphalt technology allows asphalt production and placement at reduced temperatures that could result in decreased fuel consumption, improved air quality, and an expanded asphalt pavement construction season. Because of these benefits, use of warm-mix asphalt is being promoted as part of FHWA's Every Day Counts initiative and is becoming widespread. At the same time, there are still questions related to its performance in the long term. To assess warm-mix asphalt's long-term performance, FHWA will monitor the performance of warm-mix asphalt in several locations and under different conditions, such as varying traffic flows as part of the long-term pavement performance research. This research effort will identify the key factors affecting the performance of warm-mix asphalt, and provide information to support the development of updated specifications and guidance for the use of this material as an alternative to traditional asphalt mixes.

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## Additional Resources

- [Long-Term Pavement Performance Program Web Site](#)
- [Long-Term Bridge Performance Program Project](#)

## Improving Infrastructure Condition Monitoring and Data Management

Monitoring Pavement Using Self-Powered Wireless Sensor Systems is among the projects FHWA is pursuing to improve infrastructure condition monitoring. Improperly maintained roadway pavement can pose safety hazards, such as potholes, cracking, and pavement edge failure. FHWA is researching technologies that monitor long-term pavement health, such as self-powered wireless sensor systems that can be embedded in roadway pavement. These technologies help detect pavement degradation early on, and compile data that stakeholders can use to implement long-term maintenance work plans or pavement performance programs. Overall, this research will support more effective transportation agency planning for pavement maintenance, repair, and rehabilitation that leads to increased public safety, reduced user delays and costs, improved ride quality, and long-lasting pavements.

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## Additional Resources

- [Optimization of Data Collection for Pavement Management](#)
- [Creating Smart Pavements That Monitor and Report on Pavement Condition](#)
- [Self-Powered Wireless Sensor System for Monitoring of Pavement](#)

**Objective: 3: Improve the ability of transportation agencies to deliver projects that meet expectations for timeliness, quality, and cost.**

**Strategies**

- Develop and deploy expanded and consistent use of the elements of a quality assurance program to improve infrastructure design, materials testing, construction, and inspection procedures.

**Showcase Activities**

- Providing Guidance and Tools to Improve the Core Elements of State Quality Assurance (QA) Programs

**Providing Guidance and Tools to Improve the Core Elements of State Quality Assurance (QA) Programs**

Transportation agencies must use quality assurance standards to control, monitor, and assess the construction quality of bridges, pavements, and other highway infrastructure. FHWA is developing best practices and standards to strengthen and improve core areas of agencies' quality assurance programs, such as independent assurance, dispute resolution, data validation, and acceptance procedures. Research initiatives supported by FHWA also investigate the state of the practice to identify effective strategies and tools that provide quality assurance in program delivery. FHWA shares the results of these research efforts with transportation agencies by providing training and technical assistance opportunities and by producing guidance and additional resources. As a result, transportation agencies can deliver programs more effectively and consistently to ensure high quality, safe, and reliable infrastructure construction.

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**Additional Resources**

- [Guidance and Tools to Improve the Core Elements of State Quality Assurance Programs](#)
- [Analysis of Construction Quality Assurance Procedures on Federally Funded Local Public Agency Projects](#)

**Objective: 4: Reduce user delay attributable to infrastructure system performance, maintenance, rehabilitation, and construction.**

**Strategies**

- Develop and deploy construction, inspection, maintenance, preservation, and rehabilitation practices that minimize impact to users.

**Showcase Activities**

- Accelerating Infrastructure Construction and Preservation

## Accelerating Infrastructure Construction and Preservation

FHWA has a number of projects underway to accelerate infrastructure construction and preservation. Improving Connection of Precast Concrete Bridge Deck Elements to Steel Bridge Superstructures is one such project that includes use of precast concrete bridge deck elements with steel beam superstructures to accelerate bridge construction. To achieve composite action, pockets must be formed in the deck elements to allow shear connectors to be welded and grouted onto the beam top flanges. Fit-up issues often develop in the field due to mismatched connectors and pockets in the deck elements. Limiting the longitudinal spacing of connectors to the current American Association of State Highway and Transportation Officials' design limit of 24 inches increases the number of formed pockets in the deck elements, and the likelihood of misalignment and fit-up issues. To address this, FHWA is conducting research to investigate the static and fatigue behavior of clustered shear connectors at extended spacings of 36 and 48 inches. The results of the research will assist engineers and other transportation decision makers to utilize precast elements more effectively and efficiently, leading to improved bridge safety, integrity, and performance, as well as reduced construction delays.

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## Additional Resources

- [Quantification of Cost, Benefits, and Risk Associated With Different Quality and Project Delivery Systems](#)
- [Application of Risk-Based Life-Cycle Cost/Benefits Analysis in Design Process to Achieve Intended Service Life](#)
- [Accelerated Bridge Construction Web Site](#)

**Objective: 5: Improve highway condition and performance through increased use of design, materials, construction, and maintenance innovations.**

## Strategies

- Develop and deploy approaches to effectively and systematically preserve and improve highway infrastructure condition and performance.
- Develop and deploy design and preconstruction technologies and innovations to improve infrastructure condition, durability, service life, and constructability.
- Develop and deploy methods that will improve the quality of materials and systems used for highway infrastructure.

## Showcase Activities

- Evaluating Innovative Materials and Systems to Improve Infrastructure Durability and Longevity

## Evaluating Innovative Materials and Systems to Improve Infrastructure Durability and Longevity

Geosynthetic reinforced soil (GRS) composite structures are among the innovative materials and systems FHWA is pursuing in support of infrastructure innovation. Geosynthetic reinforced soil is soil that has been strengthened with the addition of synthetic materials such as geotextile fabric sheets. The solution is used to create Integrated Bridge Systems, where the reinforced soil replaces conventional bridge abutments. Bridges built with this technology are durable, cost-effective, and exceed American Association of State Highway and Transportation Officials' bridge-design loading requirements. FHWA is researching the performance of geosynthetic reinforced soil by applying different loads to blocks of geosynthetic reinforced soil. The resulting deformations are evaluated to better understand the performance of geosynthetic reinforced soil composites. Through this research, FHWA will build a database of geosynthetic reinforced soil material properties, assess how different loading conditions affect the soil, and validate methodologies to assess the stability of the soil. This research will assist engineers, designers, and other transportation stakeholders in understanding the conditions in which geosynthetic reinforced soil performs best.

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## Additional Resources

- [Geosynthetic Reinforced Soil \(GRS\) Integrated Bridge System \(IBS\)](#)
- [Ultra-High Performance Concrete](#)

**Objective: 6: Reduce the life-cycle environmental impacts of highway infrastructure (design, construction, operation, and maintenance).**

**Strategies**

- Advance and increase the use of renewable, reusable, and recycled materials in highway-related infrastructure.

**Showcase Activities**

- Advancing the Use of Renewable, Reusable, and Recycled Materials to Achieve Durable Highway Infrastructure

**Advancing the Use of Renewable, Reusable, and Recycled Materials to Achieve Durable Highway Infrastructure**

Optimizing the Use of Recycled Asphalt in Pavement Infrastructure is one of many FHWA projects advancing the use of renewable, reuseable, and recycled materials. The costs of construction materials are rising, as is public concern for the environmental impacts of transportation construction. It is becoming increasingly important to identify and utilize cost-effective and sustainable roadway construction materials, such as recycled asphalt pavements. Incorporating recycled asphalt into pavement mixtures, and producing the material at low temperatures, result in decreased asphalt consumption and improved air quality, although the performance of recycled asphalt pavements is not fully understood. FHWA is building and testing full-scale pavements that contain FHWA levels of recycled asphalt content to assess performance. This research also will help to identify optimal temperature conditions for production of recycled asphalt pavements and ideal ratios for recycled content in pavement mixtures.

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**Additional Resources**

- [Advance Use of Recycled Asphalt in Flexible Pavement Infrastructure: Develop and Deploy Framework for Proper Use and Evaluation of Recycled Asphalt i](#)
- [Asphalt Sustainability Issues: Evaluation of Long-Term Performance of Recycled Additives, Including Recycled Motor Oil, Reclaimed Asphalt Pavements,](#)
- [Pavement Recycling](#)

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